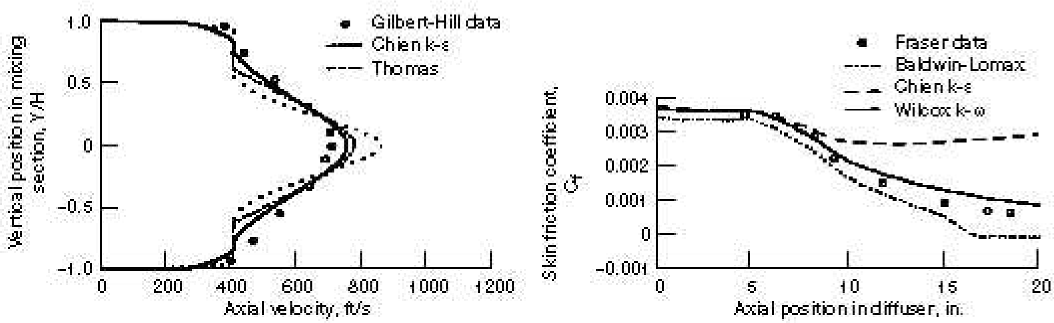
# NPARC Code Upgraded With Two-Equation Turbulence Models

The National PARC (NPARC) Alliance was established by the NASA Lewis Research Center and the Air Force Arnold Engineering Development Center to provide the U.S. aeropropulsion community with a reliable Navier-Stokes code for simulating the nonrotating components of propulsion systems. Recent improvements to the turbulence model capabilities of the NPARC code have significantly improved its capability to simulate turbulent flows. Specifically, the Chien k-epsilon and Wilcox k-omega turbulence models were implemented at Lewis.

Lewis researchers installed the Chien k-epsilon model into NPARC to improve the code's ability to calculate turbulent flows with attached wall boundary layers and free shear layers (ref. 1). Calculations with NPARC have demonstrated that the Chien k-epsilon model provides more accurate calculations than those obtained with algebraic models previously available in the code. Grid sensitivity investigations have shown that computational grids must be packed against the solid walls such that the first point off of the wall is placed in the laminar sublayer (ref. 2). In addition, matching the boundary layer and momentum thicknesses entering mixing regions is necessary for an accurate prediction of the free shear-layer growth.




*Left: Velocity profiles for an ejector nozzle flow. Right: Skin friction for the Fraser subsonic diffuser.*

Because algebraic and two-equation k-epsilon turbulence models have been found to be deficient in predicting flows with adverse pressure gradients or separations, the Wilcox k-omega model was also installed into NPARC (ref. 3). Calculations with NPARC for the Fraser diffuser (adverse pressure gradient flow) and Sajben diffuser (separated flow) have shown that the k-omega model provides the most accurate calculations among turbulence models available in NPARC for such flows.

The Chien k-epsilon and Wilcox k-omega two-equation turbulence models were installed in production versions of NPARC and are being used by the aeropropulsion community for inlet, nozzle, and propulsion-airframe integration flow problems. Additional turbulence model upgrades, including an algebraic Reynolds stress model, are planned for NPARC to make the code a state-of-the-art solver for complex turbulent flows.

# References


1. Georgiadis, N.J.; Chitsomboon, T.; and Zhu, J.: Modification of the Two-Equation Turbulence Model in NPARC to a Chien Low Reynolds Number k-epsilon Formulation. NASA TM-106710, 1994.

2. Georgiadis, N.J.; Dudek, J.C.; and Tierney, T.P.: Grid Resolution and Turbulent Inflow Boundary Condition Recommendations for NPARC Calculations. AIAA Paper 95-2613 (NASA TM-106959), 1995.

3. Yoder, D.; Georgiadis, N.J.; and Orkwis, P.: Implementation of a Two-Equation k-omega Turbulence Model in NPARC. AIAA Paper 96-0383, 1995.